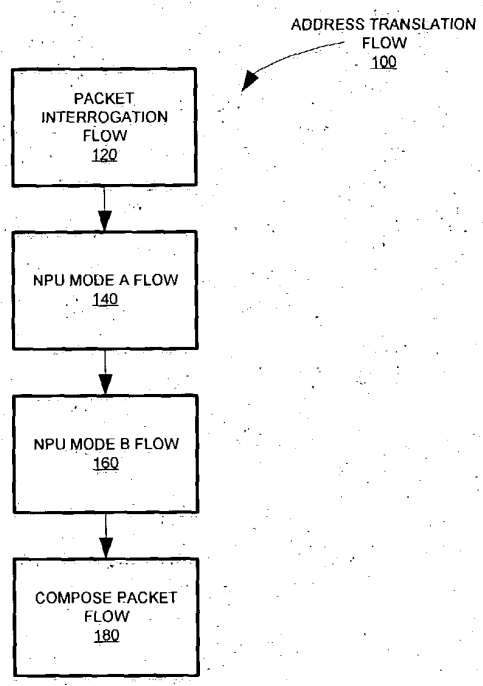
ADDRESS TRANSLATION FLOW
100
PACKET INTERROGATION FLOW
120
NPU MODE A FLOW
140
NPU MODE B FLOW
160
COMPOSE PACKET FLOW
180

FIG. 1

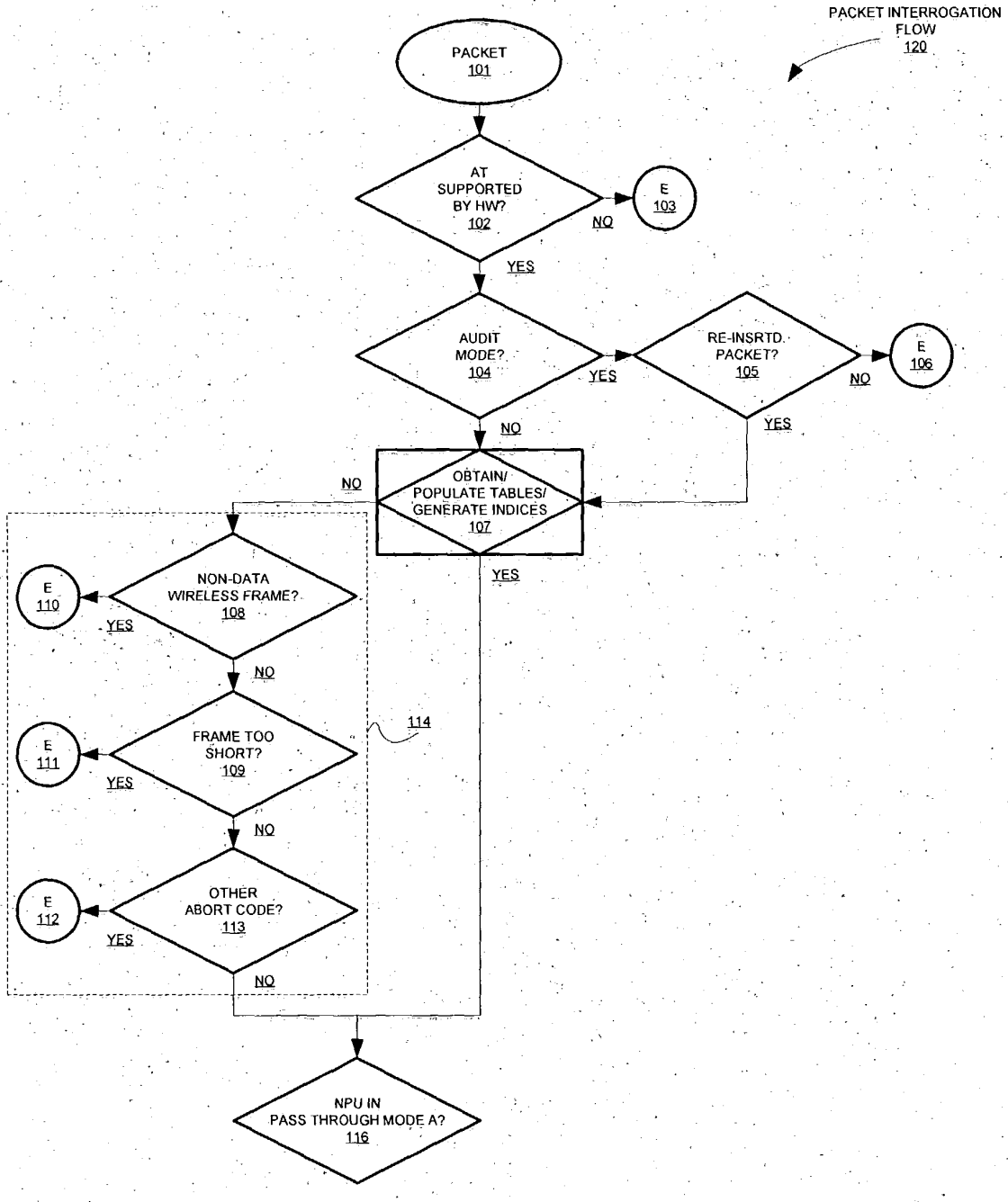
PACKET INTERROGATION FLOW
120
PACKET
101
AT SUPPORTED BY HW?
102
NO
E
103
YES
AUDIT MODE?
104
YES
RE-INSRTD. PACKET?
105
NO
E
106
YES
NO
OBTAIN/ POPULATE TABLES/ GENERATE INDICES
107
NO
YES
NON-DATA WIRELESS FRAME?
108
E
110
YES
NO
FRAME TOO SHORT?
109
E
111
YES
114
NO
OTHER ABORT CODE?
113
E
112
YES
NO
NPU IN PASS THROUGH MODE A?
116

FIG. 2A-1

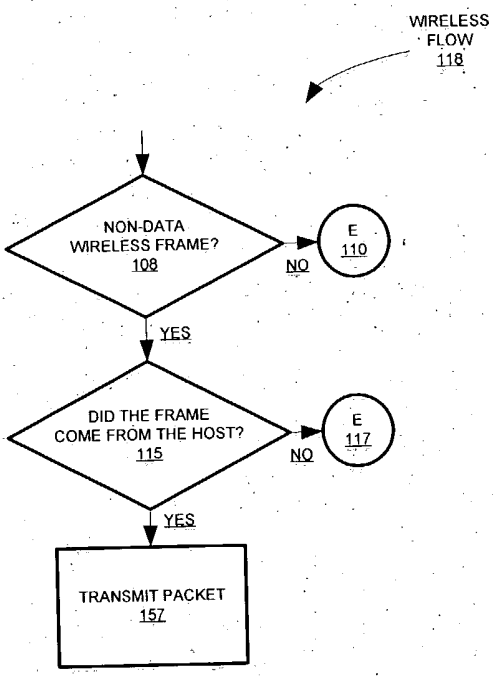
WIRELESS FLOW 118
NON-DATA WIRELESS FRAME? 108
NO
E 110
YES
DID THE FRAME COME FROM THE HOST? 115
NO
E 117
YES
TRANSMIT PACKET 157

FIG. 2A-2

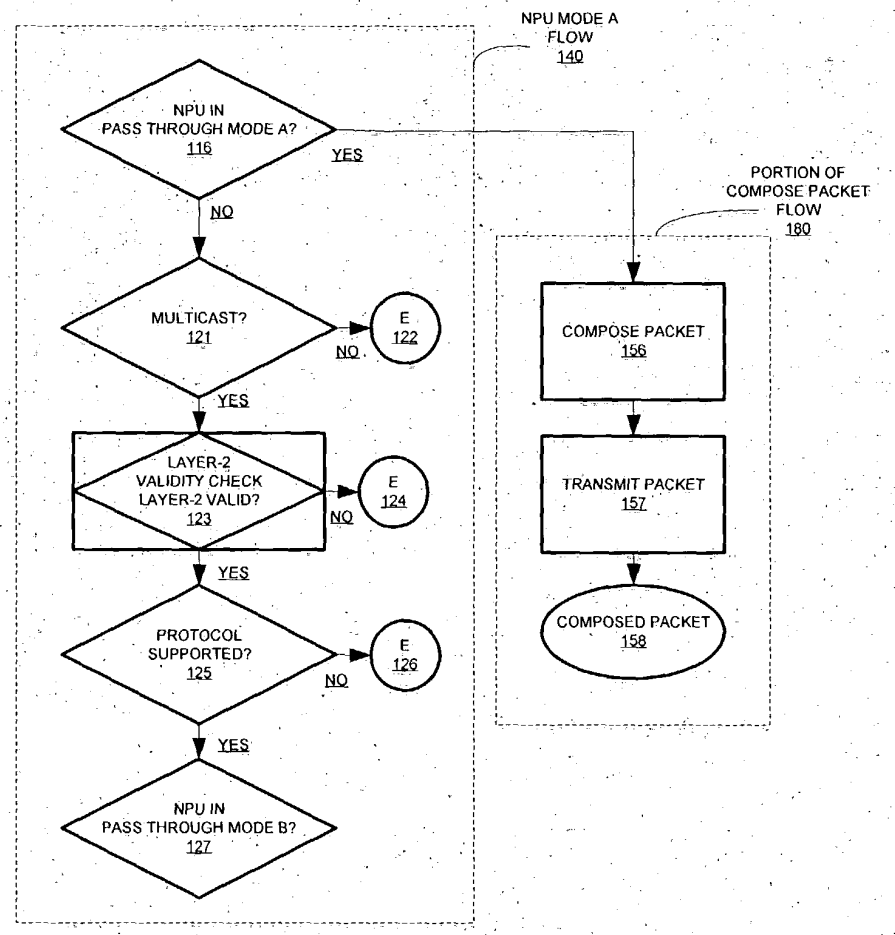
NPU MODE A FLOW 140
NPU IN PASS THROUGH MODE A? 116
YES
NO
PORTION OF COMPOSE PACKET FLOW 180
MULTICAST? 121
NO
E 122
YES
LAYER-2 VALIDITY CHECK LAYER-2 VALID? 123
NO
E 124
YES
PROTOCOL SUPPORTED? 125
NO
E 126
YES
NPU IN PASS THROUGH MODE B? 127
COMPOSE PACKET 156
TRANSMIT PACKET 157
COMPOSED PACKET 158

FIG. 2B-1

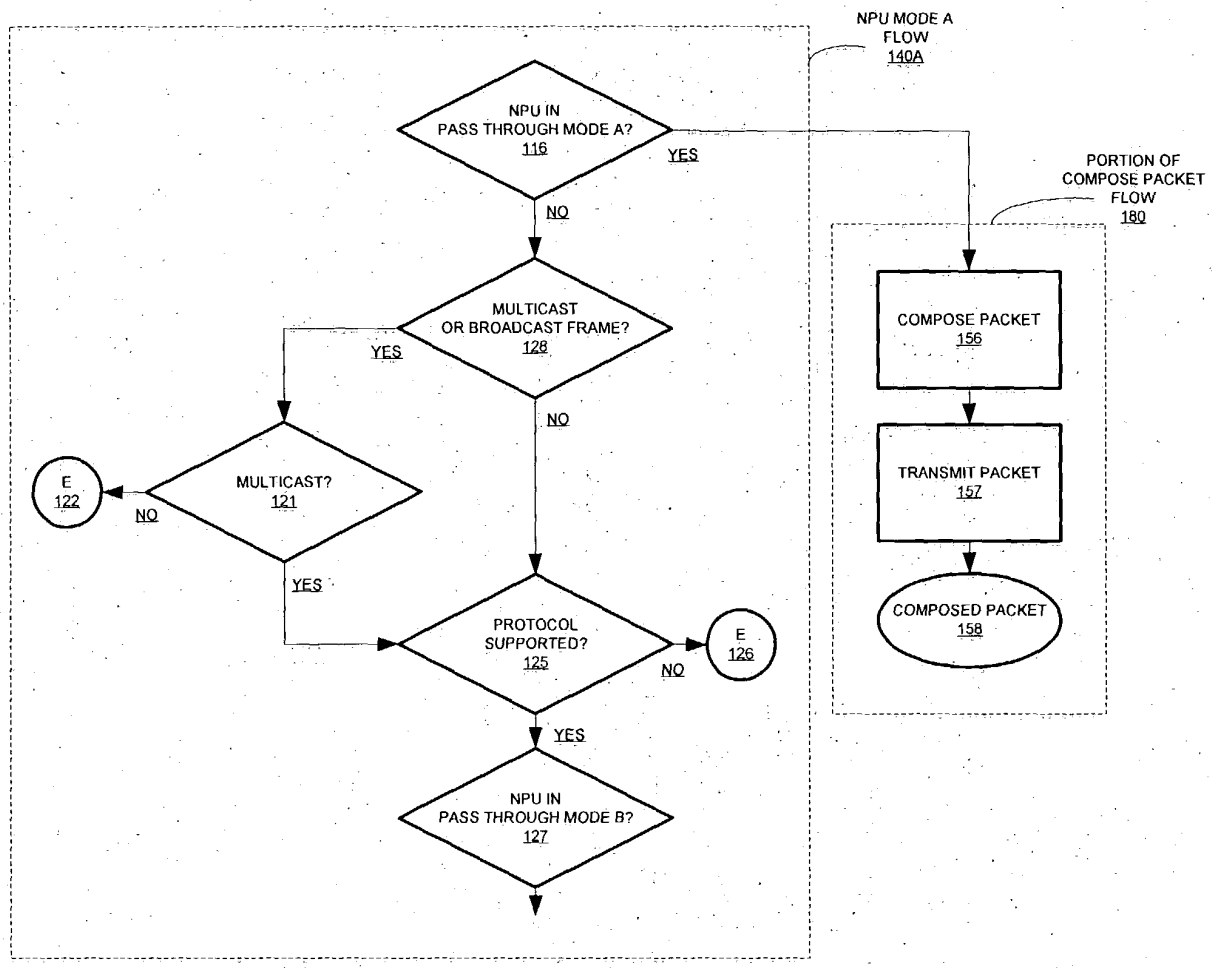
NPU MODE A FLOW 140A
NPU IN PASS THROUGH MODE A? 116
YES
NO
PORTION OF COMPOSE PACKET FLOW 180
COMPOSE PACKET 156
TRANSMIT PACKET 157
COMPOSED PACKET 158
MULTICAST OR BROADCAST FRAME? 128
YES
NO
MULTICAST? 121
NO
E 122
YES
PROTOCOL SUPPORTED? 125
NO
E 126
YES
NPU IN PASS THROUGH MODE B? 127

FIG. 2B-2

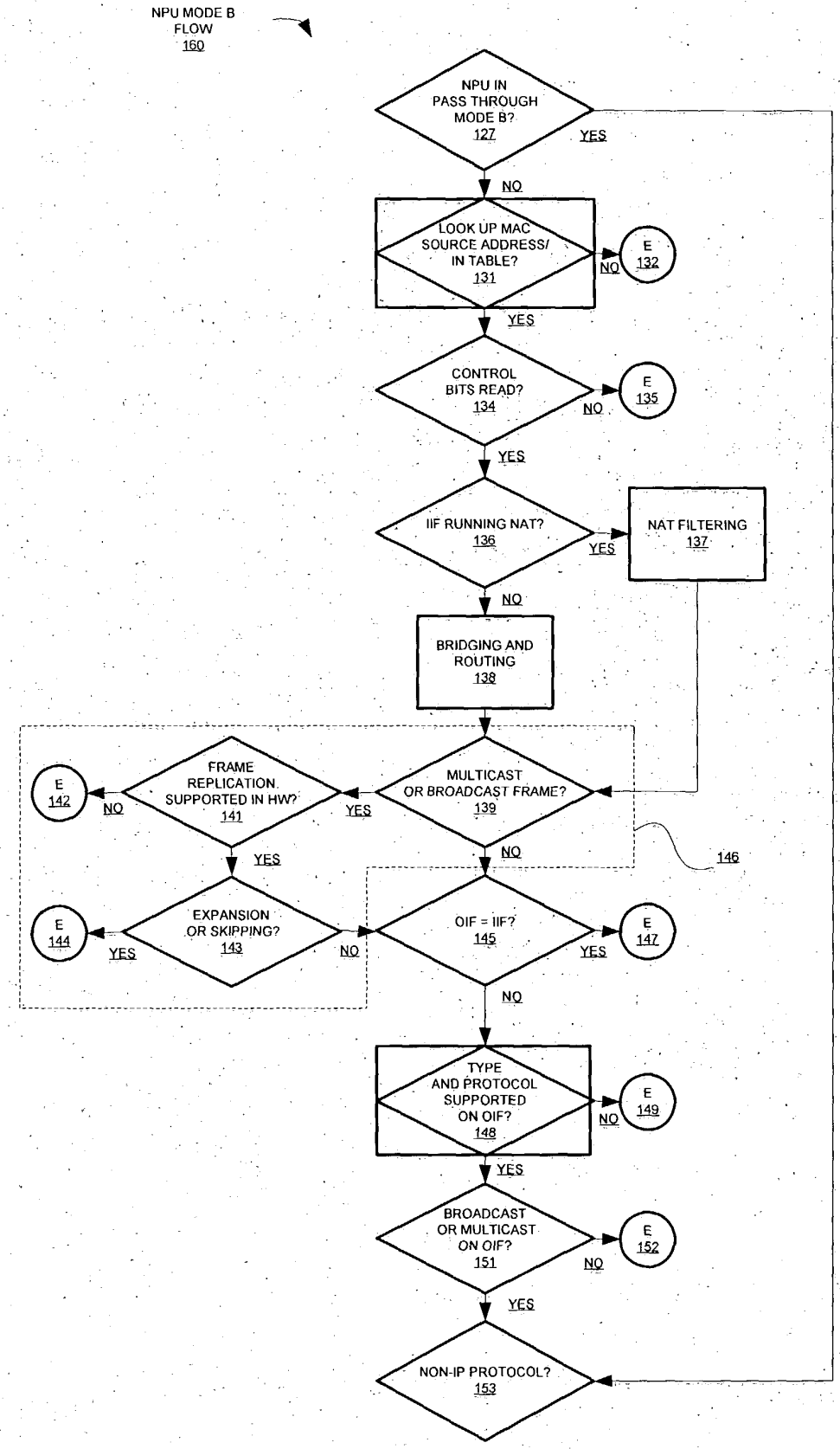
NPU MODE B FLOW 160
NPU IN PASS THROUGH MODE B? 127
YES
NO
LOOK UP MAC SOURCE ADDRESS/ IN TABLE? 131
NO
E 132
YES
CONTROL BITS READ? 134
NO
E 135
YES
IIF RUNNING NAT? 136
YES
NAT FILTERING 137
NO
BRIDGING AND ROUTING 138
MULTICAST OR BROADCAST FRAME? 139
YES
FRAME REPLICATION SUPPORTED IN HW? 141
NO
E 142
YES
EXPANSION OR SKIPPING? 143
YES
E 144
NO
OIF = IIF? 145
YES
E 147
NO
146
TYPE AND PROTOCOL SUPPORTED ON OIF? 148
NO
E 149
YES
BROADCAST OR MULTICAST ON OIF? 151
NO
E 152
YES
NON-IP PROTOCOL? 153

FIG. 2C

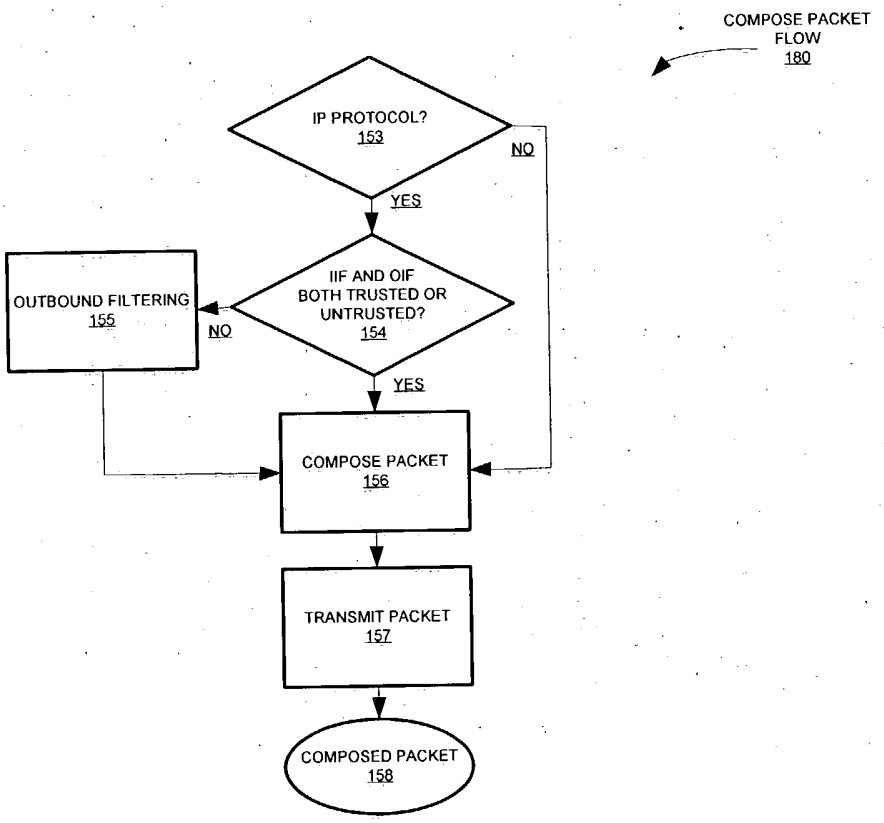
COMPOSE PACKET FLOW
180
IP PROTOCOL?
153
NO
YES
IIF AND OIF BOTH TRUSTED OR UNTRUSTED?
154
OUTBOUND FILTERING
155
NO
YES
COMPOSE PACKET
156
TRANSMIT PACKET
157
COMPOSED PACKET
158

FIG. 2D-1

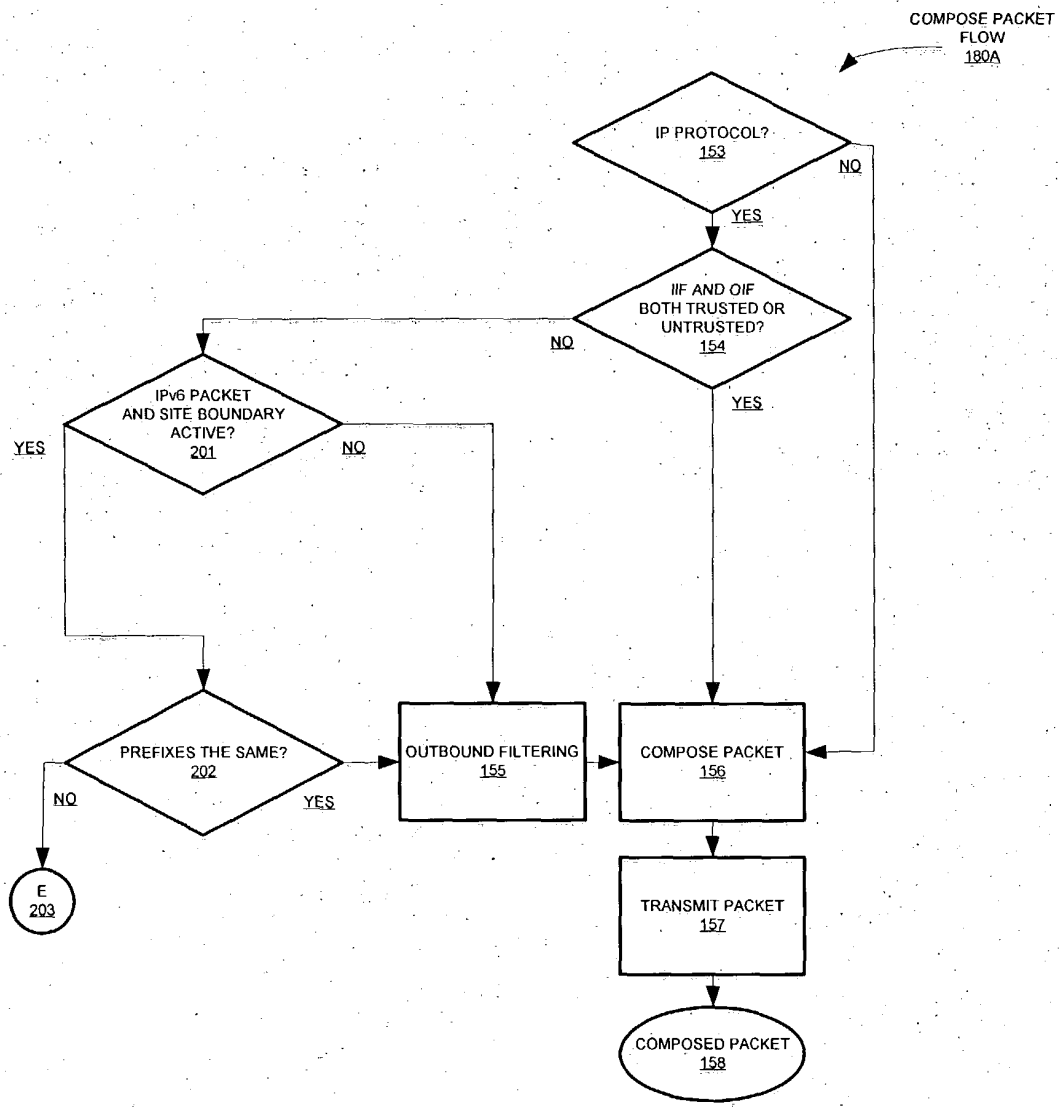
COMPOSE PACKET FLOW 180A
IP PROTOCOL? 153
NO
YES
IIF AND OIF BOTH TRUSTED OR UNTRUSTED? 154
NO
YES
IPv6 PACKET AND SITE BOUNDARY ACTIVE? 201
YES
NO
PREFIXES THE SAME? 202
NO
YES
E 203
OUTBOUND FILTERING 155
COMPOSE PACKET 156
TRANSMIT PACKET 157
COMPOSED PACKET 158

FIG. 2D-2

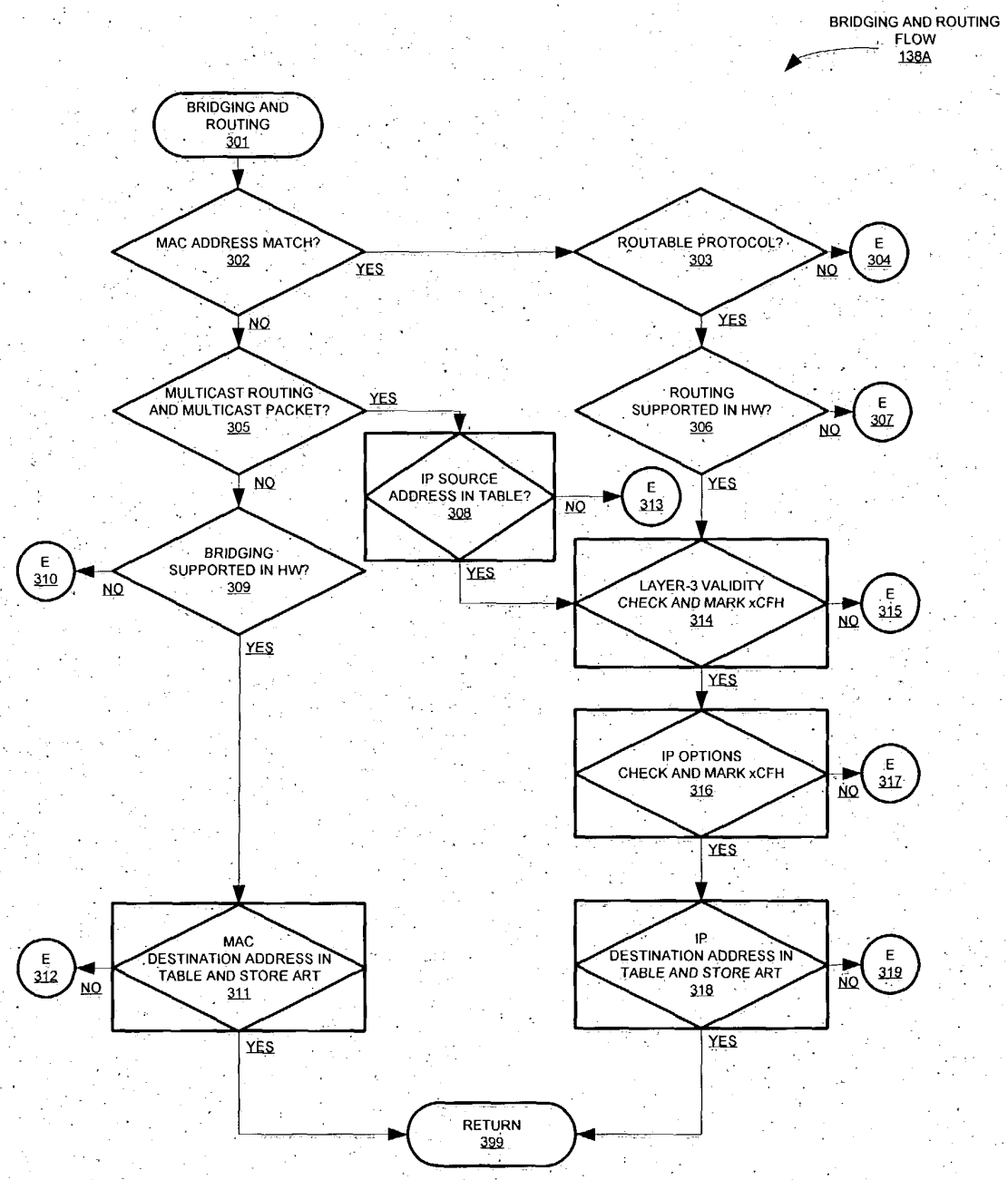
BRIDGING AND ROUTING FLOW
138A
BRIDGING AND ROUTING
301
MAC ADDRESS MATCH?
302
YES
NO
ROUTABLE PROTOCOL?
303
NO
E
304
YES
MULTICAST ROUTING AND MULTICAST PACKET?
305
YES
NO
ROUTING SUPPORTED IN HW?
306
NO
E
307
YES
IP SOURCE ADDRESS IN TABLE?
308
NO
E
313
YES
BRIDGING SUPPORTED IN HW?
309
NO
E
310
YES
LAYER-3 VALIDITY CHECK AND MARK xCFH
314
NO
E
315
YES
IP OPTIONS CHECK AND MARK xCFH
316
NO
E
317
YES
MAC DESTINATION ADDRESS IN TABLE AND STORE ART
311
NO
E
312
YES
IP DESTINATION ADDRESS IN TABLE AND STORE ART
318
NO
E
319
YES
RETURN
399

FIG. 3A

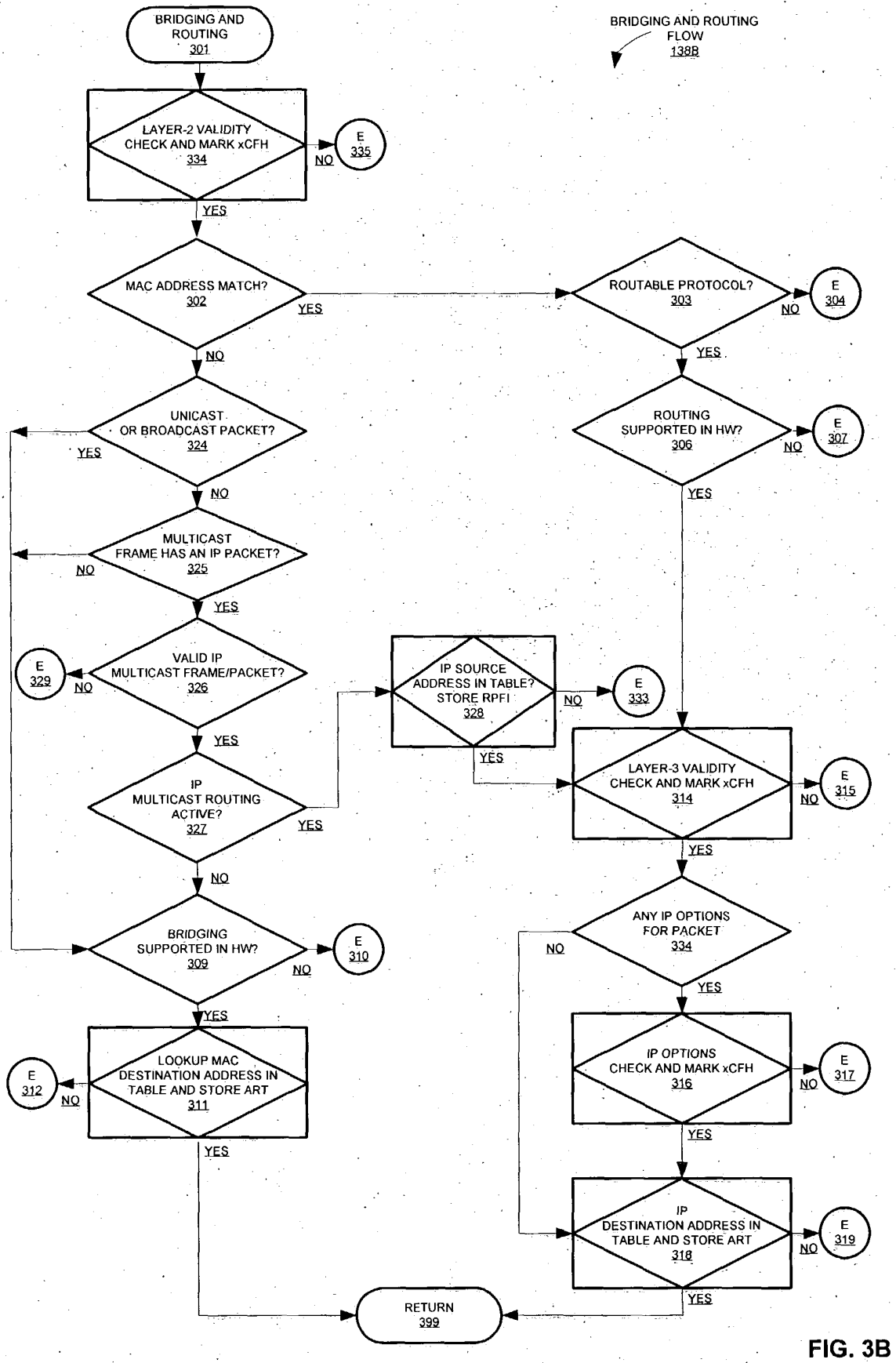
BRIDGING AND ROUTING 301
BRIDGING AND ROUTING FLOW 138B
LAYER-2 VALIDITY CHECK AND MARK xCFH 334
E 335
NO
YES
MAC ADDRESS MATCH? 302
YES
ROUTABLE PROTOCOL? 303
NO
E 304
YES
NO
UNICAST OR BROADCAST PACKET? 324
YES
ROUTING SUPPORTED IN HW? 306
NO
E 307
YES
NO
MULTICAST FRAME HAS AN IP PACKET? 325
NO
YES
E 329
VALID IP MULTICAST FRAME/PACKET? 326
NO
IP SOURCE ADDRESS IN TABLE? STORE RPFI 328
NO
E 333
YES
YES
IP MULTICAST ROUTING ACTIVE? 327
YES
LAYER-3 VALIDITY CHECK AND MARK xCFH 314
NO
E 315
YES
NO
BRIDGING SUPPORTED IN HW? 309
NO
E 310
ANY IP OPTIONS FOR PACKET 334
NO
YES
YES
E 312
NO
LOOKUP MAC DESTINATION ADDRESS IN TABLE AND STORE ART 311
IP OPTIONS CHECK AND MARK xCFH 316
NO
E 317
YES
YES
IP DESTINATION ADDRESS IN TABLE AND STORE ART 318
NO
E 319
YES
RETURN 399

FIG. 3B

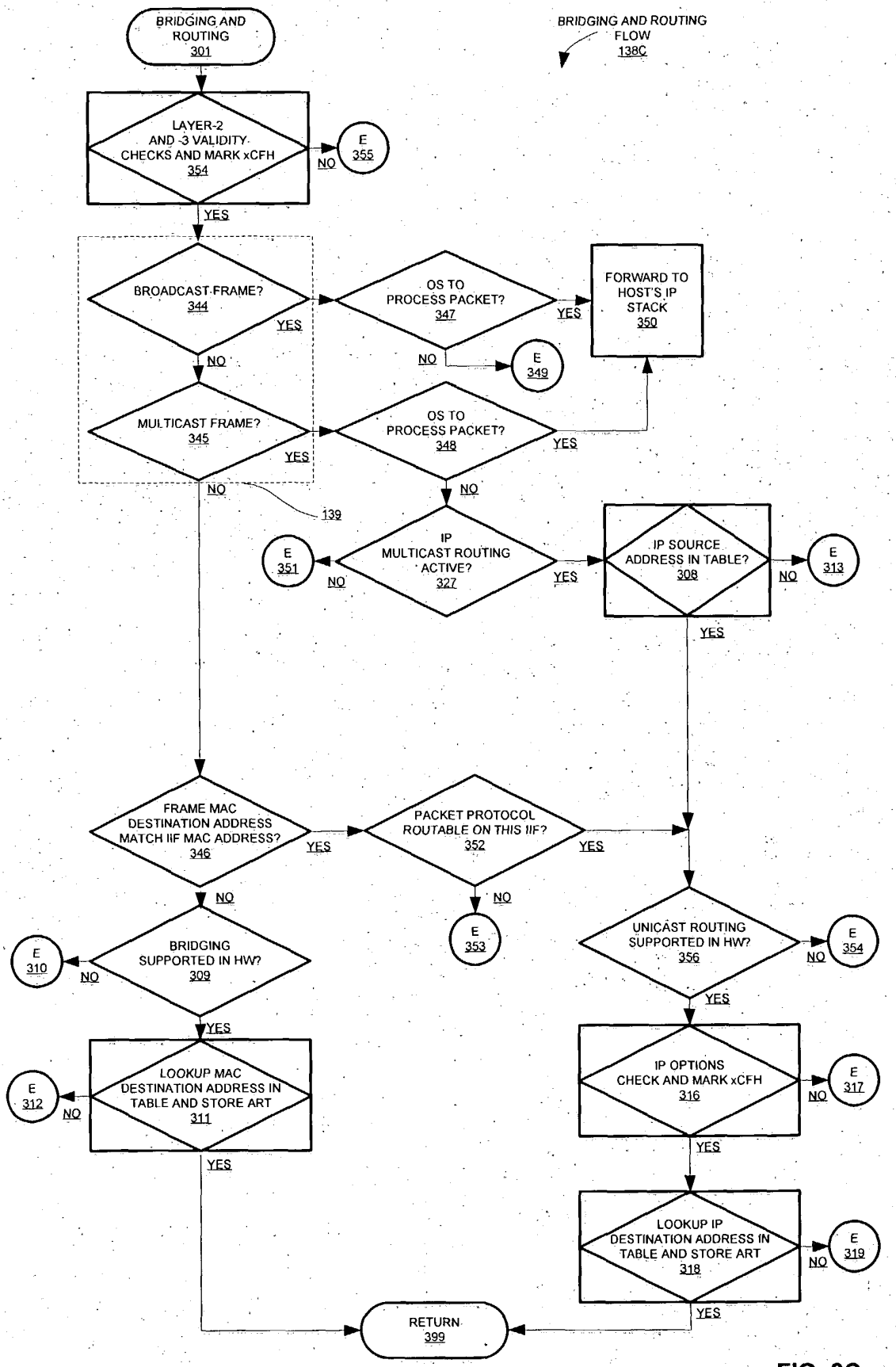
BRIDGING AND ROUTING 301
BRIDGING AND ROUTING FLOW 138C
LAYER-2 AND -3 VALIDITY CHECKS AND MARK xCFH 354
NO
E 355
YES
BROADCAST FRAME? 344
YES
NO
OS TO PROCESS PACKET? 347
YES
NO
E 349
FORWARD TO HOST'S IP STACK 350
MULTICAST FRAME? 345
YES
NO
OS TO PROCESS PACKET? 348
YES
NO
139
IP MULTICAST ROUTING ACTIVE? 327
NO
E 351
YES
IP SOURCE ADDRESS IN TABLE? 308
NO
E 313
YES
FRAME MAC DESTINATION ADDRESS MATCH IIF MAC ADDRESS? 346
YES
NO
PACKET PROTOCOL ROUTABLE ON THIS IIF? 352
YES
NO
E 353
BRIDGING SUPPORTED IN HW? 309
NO
E 310
YES
LOOKUP MAC DESTINATION ADDRESS IN TABLE AND STORE ART 311
NO
E 312
YES
UNICAST ROUTING SUPPORTED IN HW? 356
NO
E 354
YES
IP OPTIONS CHECK AND MARK xCFH 316
NO
E 317
YES
LOOKUP IP DESTINATION ADDRESS IN TABLE AND STORE ART 318
NO
E 319
YES
RETURN 399

FIG. 3C

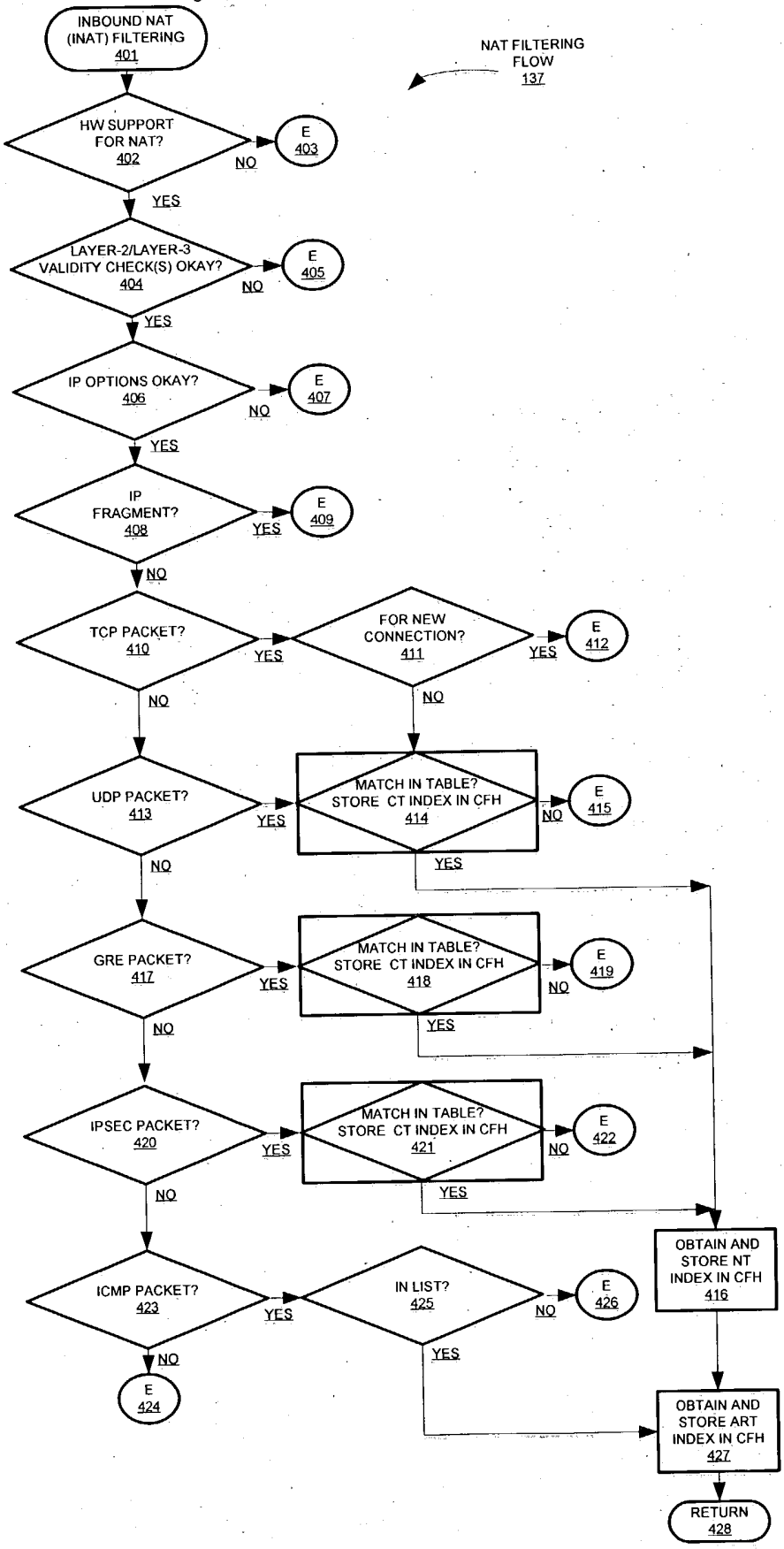
INBOUND NAT (INAT) FILTERING 401
NAT FILTERING FLOW 137
HW SUPPORT FOR NAT? 402
NO
E 403
YES
LAYER-2/LAYER-3 VALIDITY CHECK(S) OKAY? 404
NO
E 405
YES
IP OPTIONS OKAY? 406
NO
E 407
YES
IP FRAGMENT? 408
YES
E 409
NO
TCP PACKET? 410
YES
FOR NEW CONNECTION? 411
YES
E 412
NO
NO
UDP PACKET? 413
YES
MATCH IN TABLE? STORE CT INDEX IN CFH 414
NO
E 415
YES
NO
GRE PACKET? 417
YES
MATCH IN TABLE? STORE CT INDEX IN CFH 418
NO
E 419
YES
NO
IPSEC PACKET? 420
YES
MATCH IN TABLE? STORE CT INDEX IN CFH 421
NO
E 422
YES
NO
ICMP PACKET? 423
YES
IN LIST? 425
NO
E 426
YES
NO
E 424
OBTAIN AND STORE NT INDEX IN CFH 416
OBTAIN AND STORE ART INDEX IN CFH 427
RETURN 428

FIG. 4A

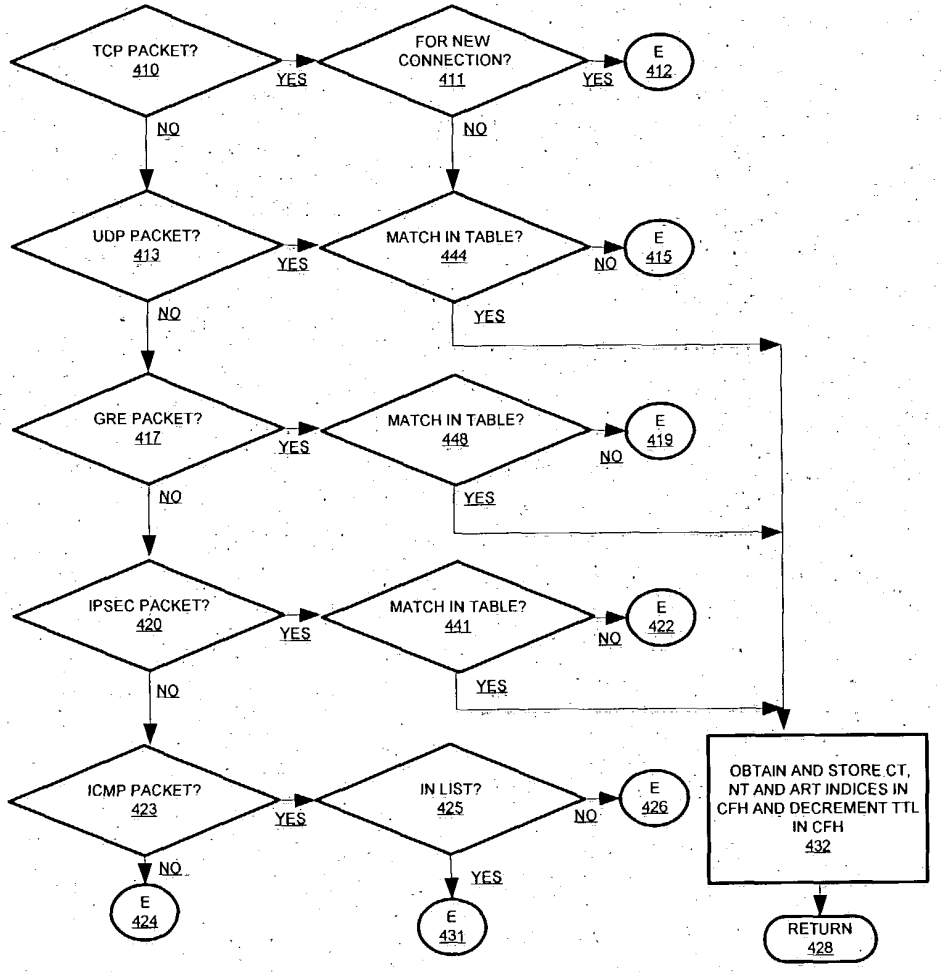
TCP PACKET? 410
YES
FOR NEW CONNECTION? 411
YES
E 412
NO
NO
UDP PACKET? 413
YES
MATCH IN TABLE? 444
NO
E 415
NO
YES
GRE PACKET? 417
YES
MATCH IN TABLE? 448
NO
E 419
NO
YES
IPSEC PACKET? 420
YES
MATCH IN TABLE? 441
NO
E 422
NO
YES
ICMP PACKET? 423
YES
IN LIST? 425
NO
E 426
NO
YES
E 424
E 431
OBTAIN AND STORE CT, NT AND ART INDICES IN CFH AND DECREMENT TTL IN CFH 432
RETURN 428

FIG. 4B

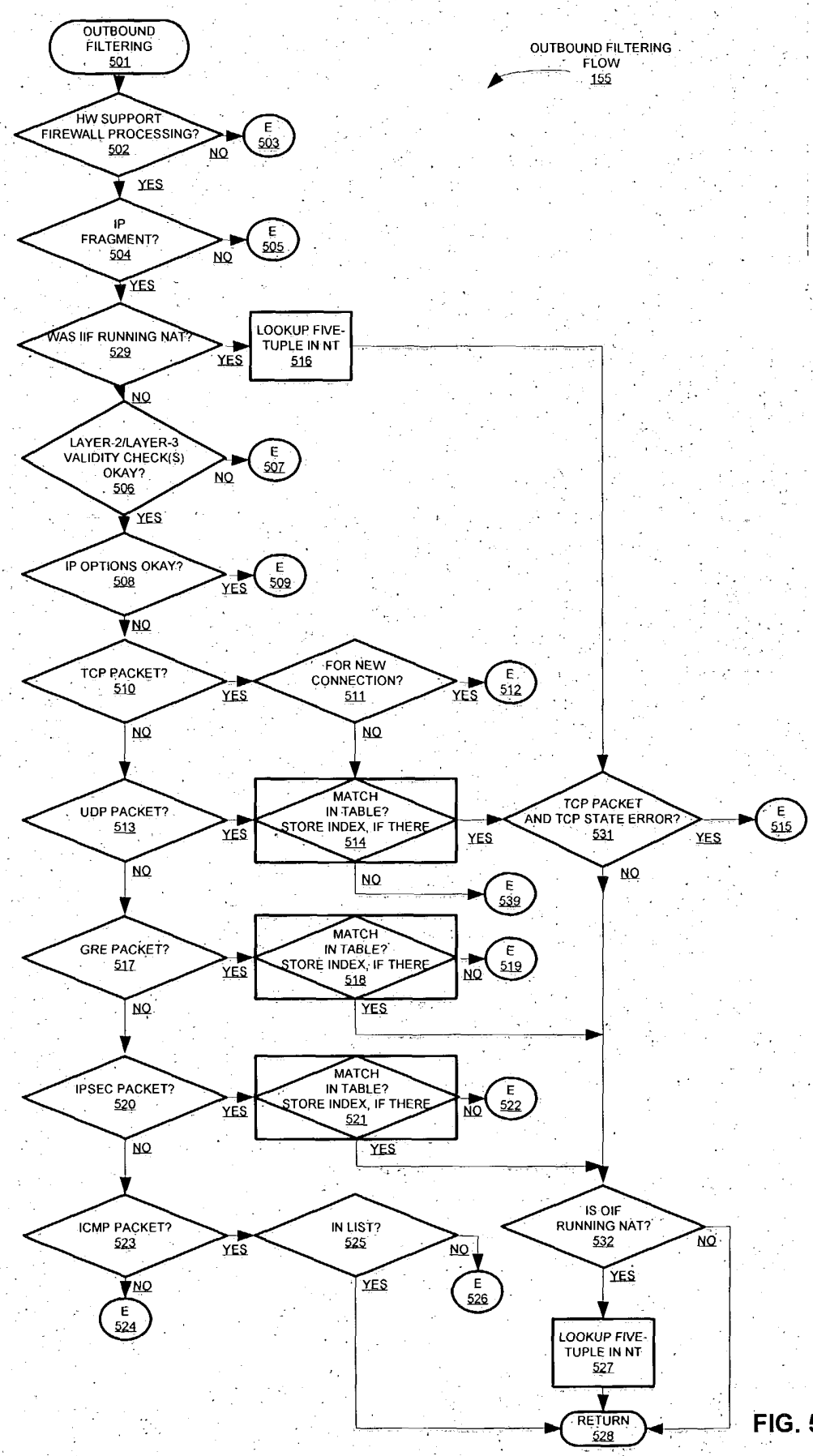
OUTBOUND FILTERING
501
OUTBOUND FILTERING FLOW
155
HW SUPPORT FIREWALL PROCESSING?
502
NO
E
503
YES
IP FRAGMENT?
504
NO
E
505
YES
WAS IIF RUNNING NAT?
529
YES
LOOKUP FIVE-TUPLE IN NT
516
NO
LAYER-2/LAYER-3 VALIDITY CHECK(S) OKAY?
506
NO
E
507
YES
IP OPTIONS OKAY?
508
YES
E
509
NO
TCP PACKET?
510
YES
FOR NEW CONNECTION?
511
YES
E
512
NO
NO
UDP PACKET?
513
YES
MATCH IN TABLE? STORE INDEX, IF THERE
514
YES
TCP PACKET AND TCP STATE ERROR?
531
YES
E
515
NO
NO
E
539
GRE PACKET?
517
YES
MATCH IN TABLE? STORE INDEX, IF THERE
518
NO
E
519
NO
YES
IPSEC PACKET?
520
YES
MATCH IN TABLE? STORE INDEX, IF THERE
521
NO
E
522
NO
YES
ICMP PACKET?
523
YES
IN LIST?
525
NO
E
526
NO
YES
E
524
IS OIF RUNNING NAT?
532
NO
YES
LOOKUP FIVE-TUPLE IN NT
527
RETURN
528

FIG. 5A

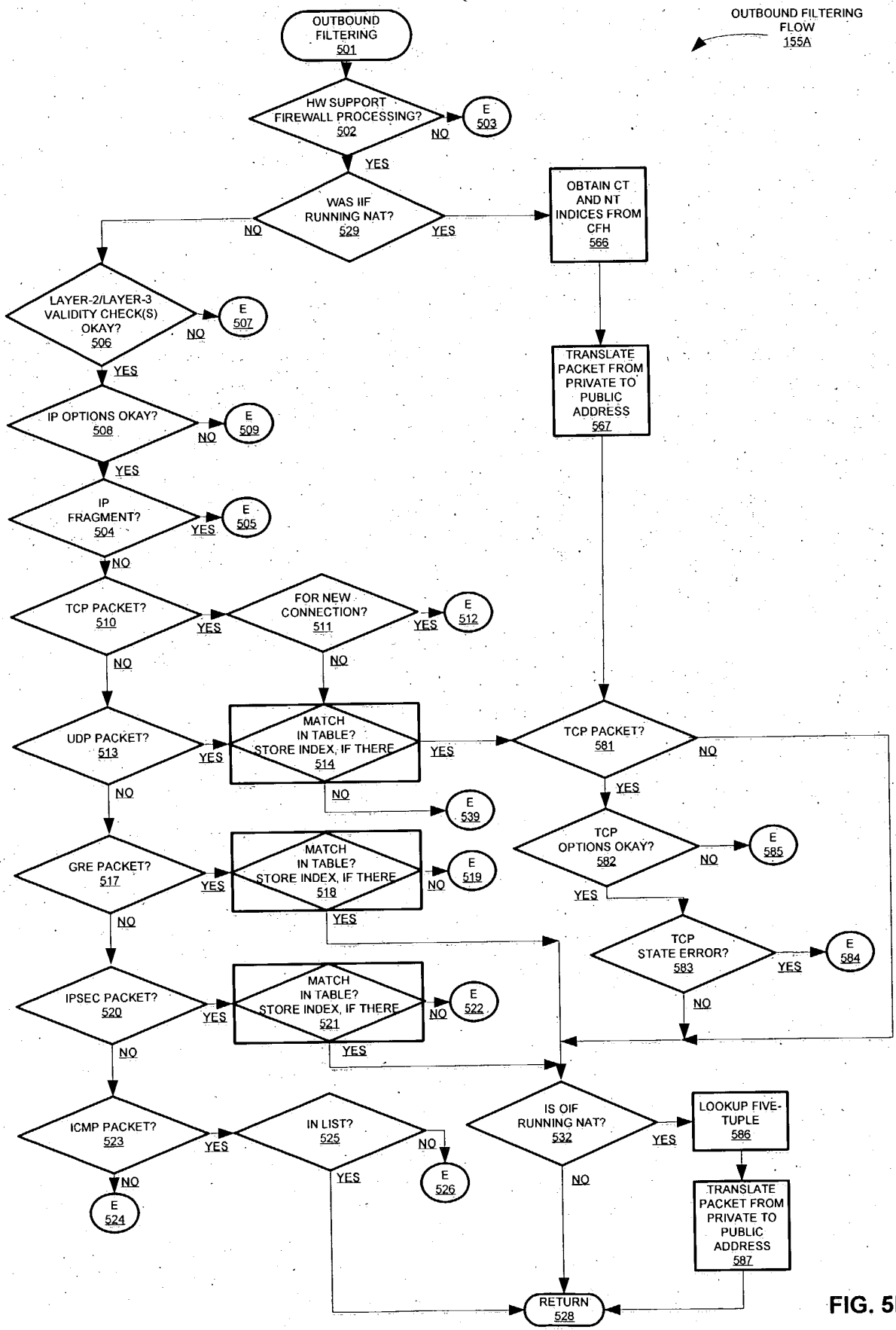
OUTBOUND FILTERING FLOW 155A
OUTBOUND FILTERING 501
HW SUPPORT FIREWALL PROCESSING? 502
E 503
NO
YES
WAS IIF RUNNING NAT? 529
NO
YES
OBTAIN CT AND NT INDICES FROM CFH 566
LAYER-2/LAYER-3 VALIDITY CHECK(S) OKAY? 506
E 507
NO
YES
TRANSLATE PACKET FROM PRIVATE TO PUBLIC ADDRESS 567
IP OPTIONS OKAY? 508
E 509
NO
YES
IP FRAGMENT? 504
E 505
YES
NO
TCP PACKET? 510
YES
FOR NEW CONNECTION? 511
YES
E 512
NO
NO
UDP PACKET? 513
YES
MATCH IN TABLE? STORE INDEX, IF THERE 514
YES
NO
E 539
TCP PACKET? 581
NO
YES
GRE PACKET? 517
YES
MATCH IN TABLE? STORE INDEX, IF THERE 518
NO
E 519
YES
TCP OPTIONS OKAY? 582
NO
E 585
YES
NO
TCP STATE ERROR? 583
YES
E 584
NO
IPSEC PACKET? 520
YES
MATCH IN TABLE? STORE INDEX, IF THERE 521
NO
E 522
YES
NO
ICMP PACKET? 523
YES
IN LIST? 525
NO
E 526
YES
NO
E 524
IS OIF RUNNING NAT? 532
YES
LOOKUP FIVE-TUPLE 586
NO
TRANSLATE PACKET FROM PRIVATE TO PUBLIC ADDRESS 587
RETURN 528

FIG. 5B

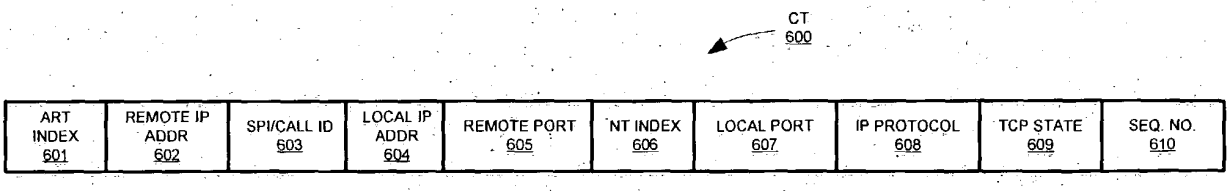

FIG. 6

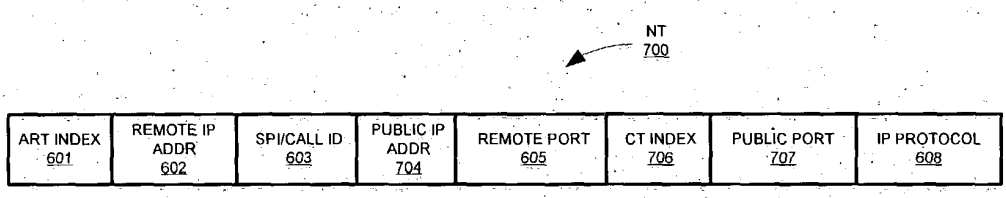

FIG. 7

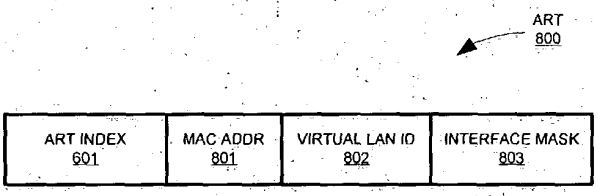

FIG. 8

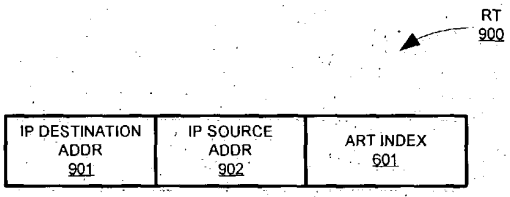

FIG. 9A

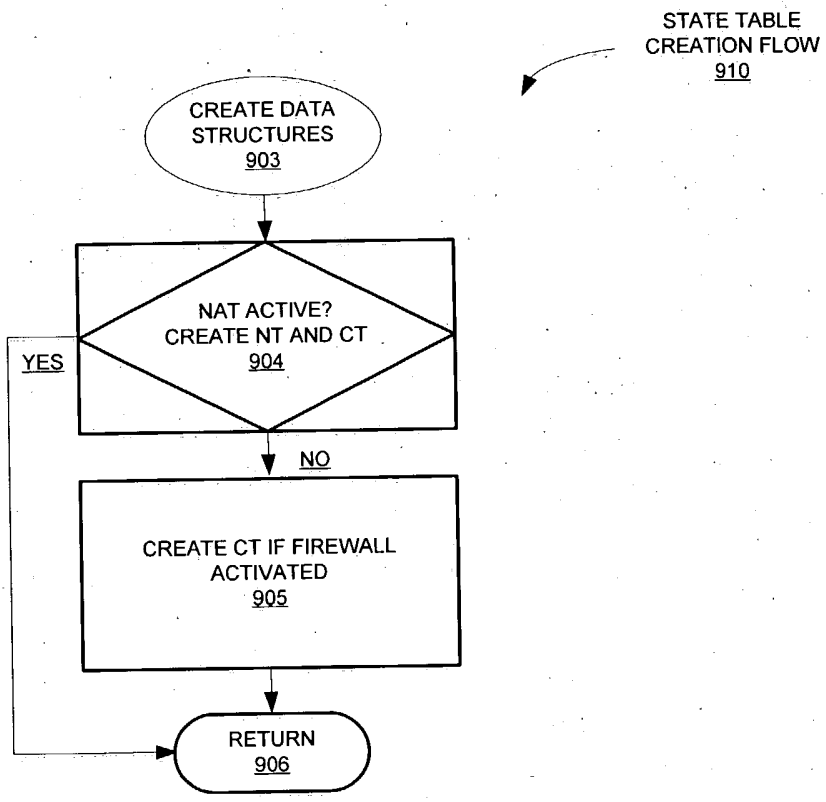
STATE TABLE CREATION FLOW
910
CREATE DATA STRUCTURES
903
NAT ACTIVE?
CREATE NT AND CT
904
YES
NO
CREATE CT IF FIREWALL ACTIVATED
905
RETURN
906

FIG. 9B

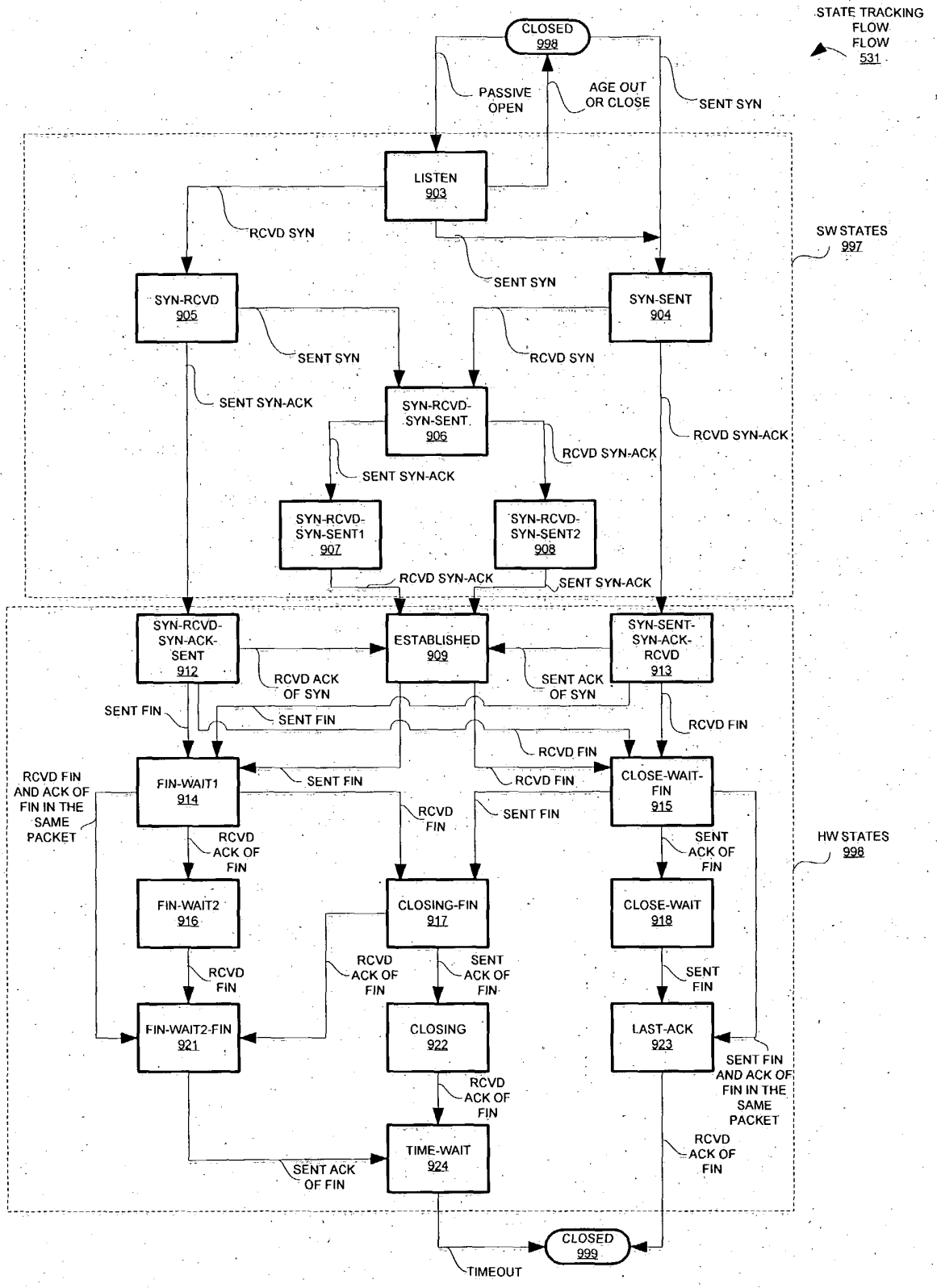
STATE TRACKING FLOW
FLOW
531
CLOSED
998
PASSIVE OPEN
AGE OUT OR CLOSE
SENT SYN
LISTEN
903
RCVD SYN
SENT SYN
SW STATES
997
SYN-RCVD
905
SYN-SENT
904
SENT SYN
RCVD SYN
SENT SYN-ACK
SYN-RCVD-SYN-SENT
906
RCVD SYN-ACK
RCVD SYN-ACK
SENT SYN-ACK
SYN-RCVD-SYN-SENT1
907
SYN-RCVD-SYN-SENT2
908
RCVD SYN-ACK
SENT SYN-ACK
SYN-RCVD-SYN-ACK-SENT
912
ESTABLISHED
909
SYN-SENT-SYN-ACK-RCVD
913
RCVD ACK OF SYN
SENT ACK OF SYN
SENT FIN
SENT FIN
RCVD FIN
RCVD FIN
RCVD FIN
SENT FIN
RCVD FIN AND ACK OF FIN IN THE SAME PACKET
FIN-WAIT1
914
CLOSE-WAIT-FIN
915
RCVD FIN
SENT FIN
HW STATES
998
RCVD ACK OF FIN
SENT ACK OF FIN
FIN-WAIT2
916
CLOSING-FIN
917
CLOSE-WAIT
918
RCVD FIN
RCVD ACK OF FIN
SENT ACK OF FIN
SENT FIN
FIN-WAIT2-FIN
921
CLOSING
922
LAST-ACK
923
SENT FIN AND ACK OF FIN IN THE SAME PACKET
RCVD ACK OF FIN
TIME-WAIT
924
RCVD ACK OF FIN
SENT ACK OF FIN
CLOSED
999
TIMEOUT

FIG. 10

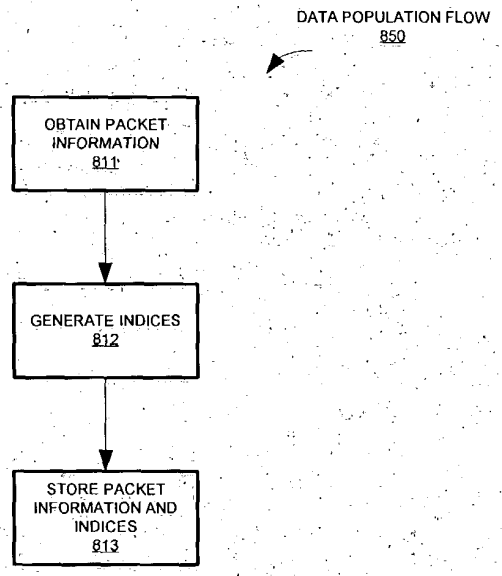
DATA POPULATION FLOW
850
OBTAIN PACKET INFORMATION
811
GENERATE INDICES
812
STORE PACKET INFORMATION AND INDICES
813

FIG. 11

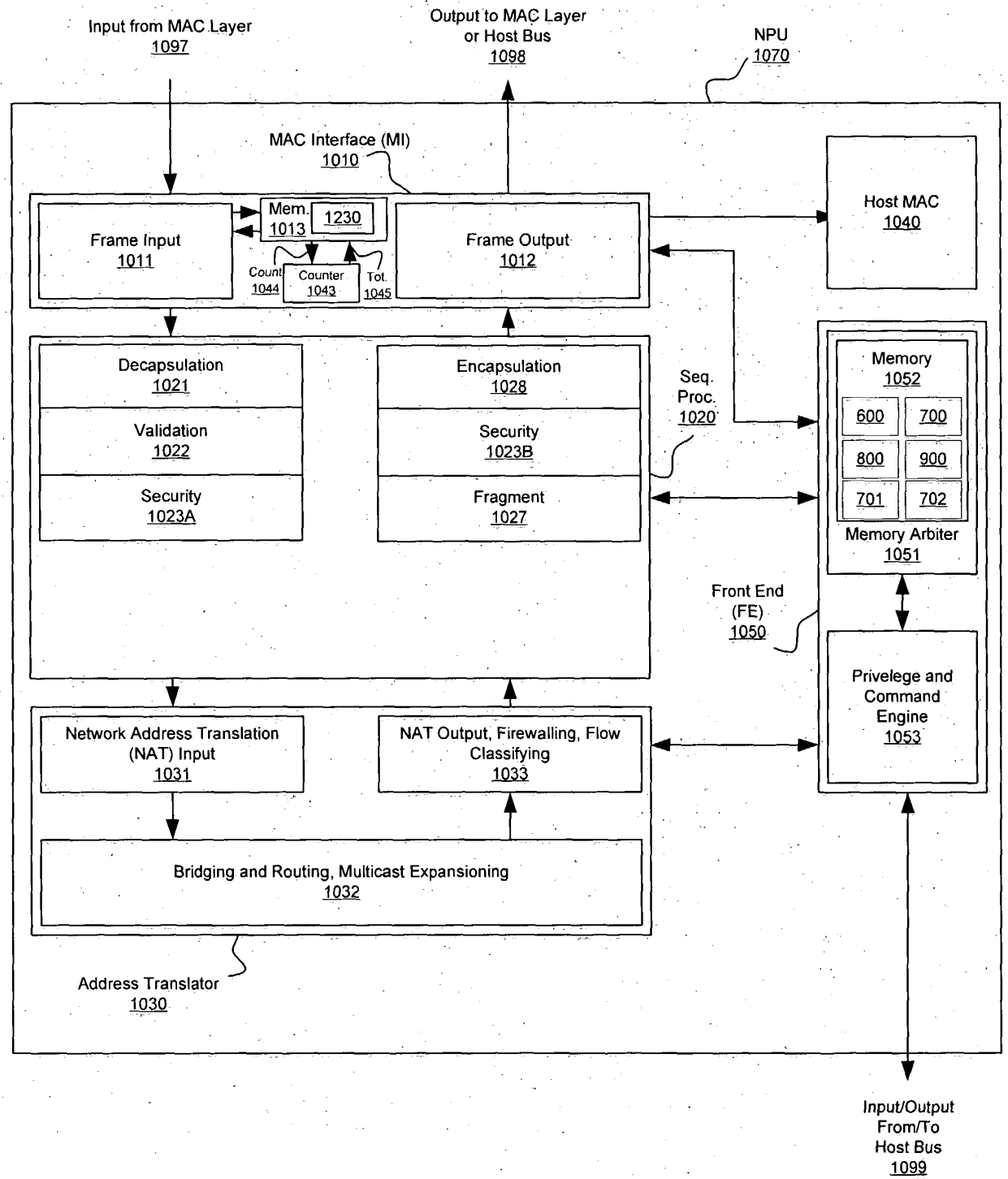
Input from MAC Layer
1097
Output to MAC Layer or Host Bus
1098
NPU
1070
MAC Interface (MI)
1010
Host MAC
1040
Frame Input
1011
Mem.
1013
1230
Count
1044
Counter
1043
Tot.
1045
Frame Output
1012
Decapsulation
1021
Validation
1022
Security
1023A
Encapsulation
1028
Security
1023B
Fragment
1027
Seq. Proc.
1020
Memory
1052
600
700
800
900
701
702
Memory Arbiter
1051
Front End (FE)
1050
Privelege and Command Engine
1053
Network Address Translation (NAT) Input
1031
NAT Output, Firewalling, Flow Classifying
1033
Bridging and Routing, Multicast Expansioning
1032
Address Translator
1030
Input/Output From/To Host Bus
1099

FIG. 12A

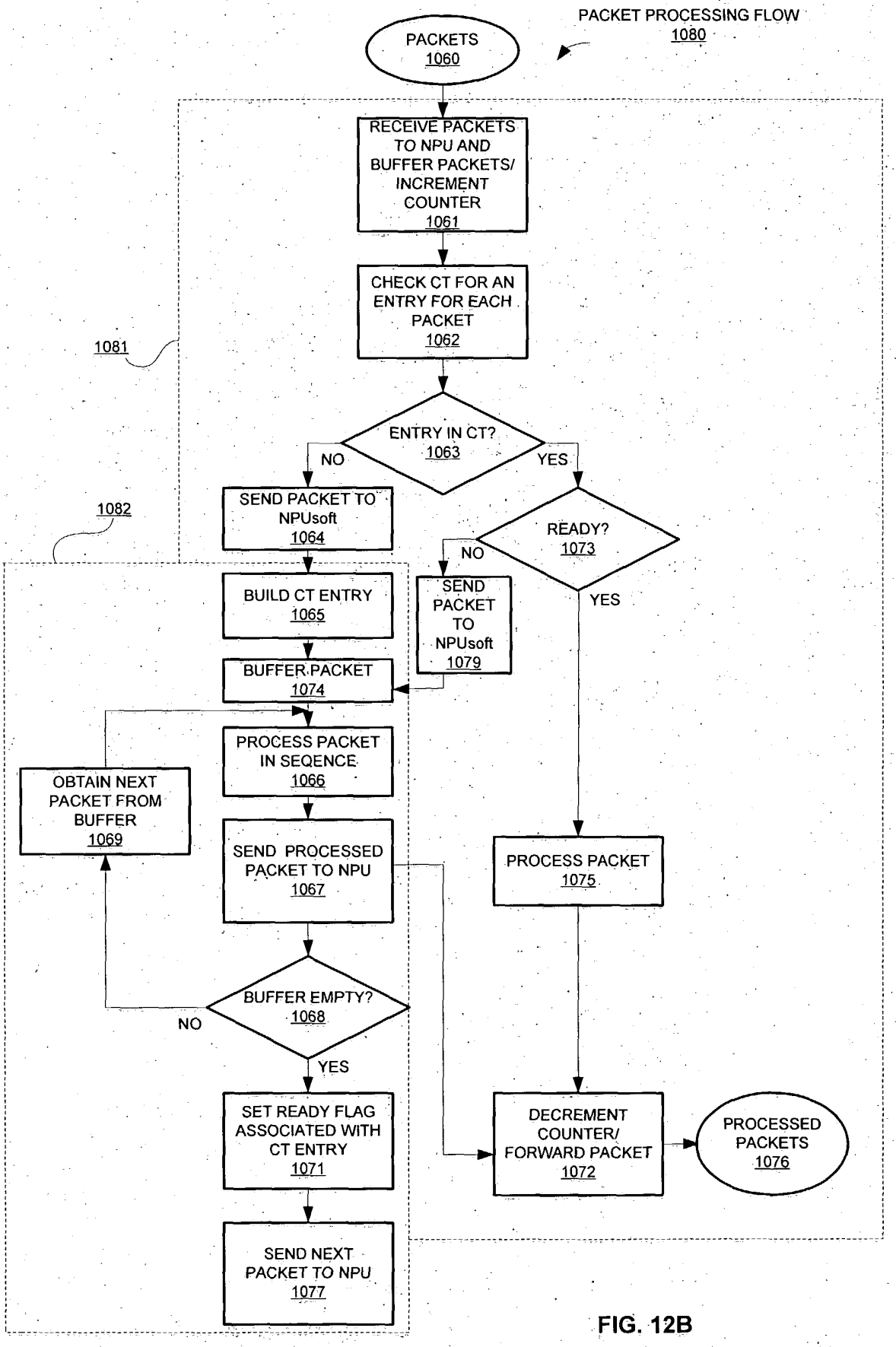
PACKET PROCESSING FLOW
1080
PACKETS
1060
RECEIVE PACKETS TO NPU AND BUFFER PACKETS/ INCREMENT COUNTER
1061
CHECK CT FOR AN ENTRY FOR EACH PACKET
1062
1081
ENTRY IN CT?
1063
NO
YES
SEND PACKET TO NPUsoft
1064
1082
READY?
1073
NO
YES
BUILD CT ENTRY
1065
SEND PACKET TO NPUsoft
1079
BUFFER PACKET
1074
PROCESS PACKET IN SEQENCE
1066
OBTAIN NEXT PACKET FROM BUFFER
1069
SEND PROCESSED PACKET TO NPU
1067
PROCESS PACKET
1075
BUFFER EMPTY?
1068
NO
YES
SET READY FLAG ASSOCIATED WITH CT ENTRY
1071
DECREMENT COUNTER/ FORWARD PACKET
1072
PROCESSED PACKETS
1076
SEND NEXT PACKET TO NPU
1077

FIG. 12B

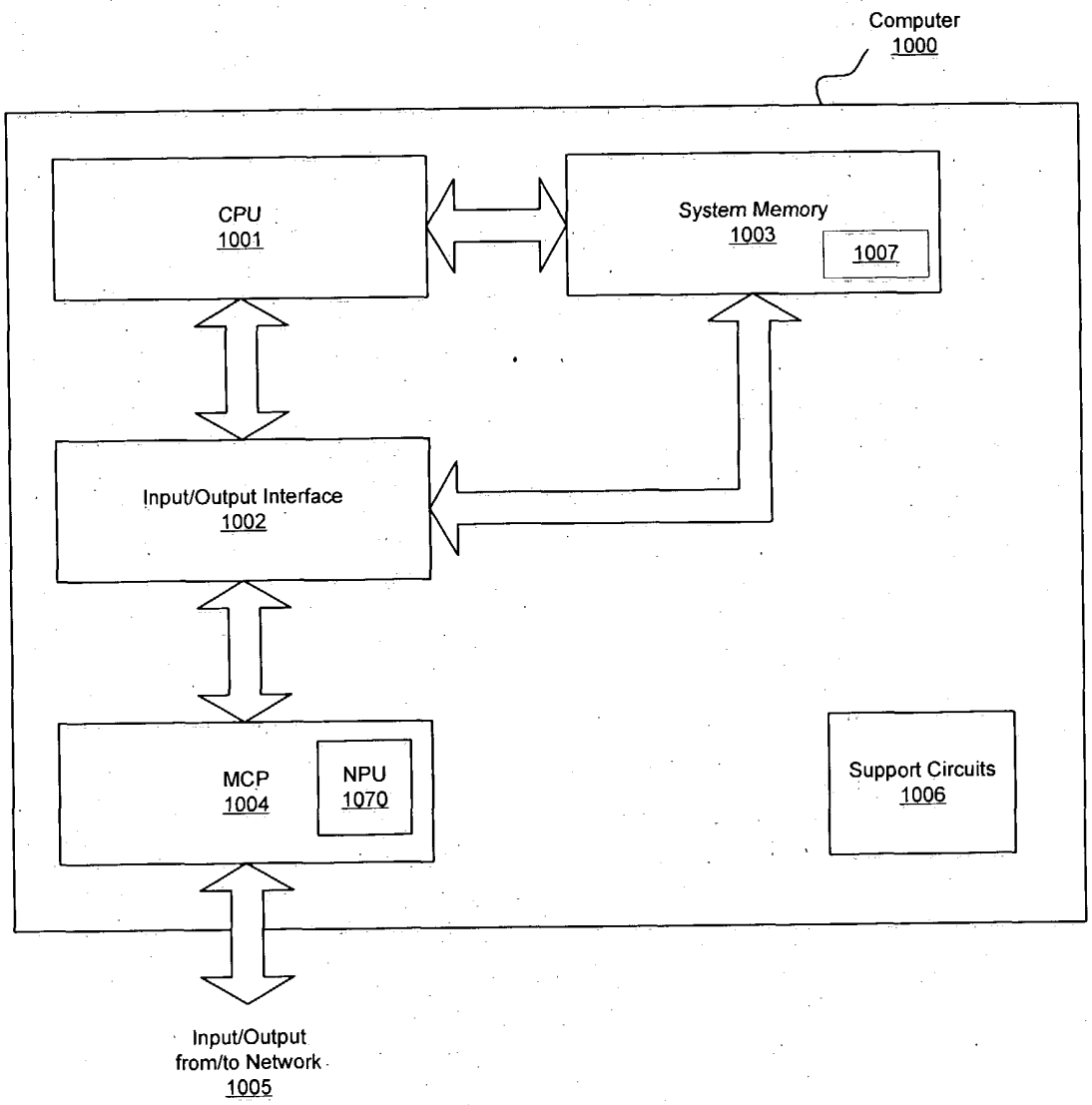
Computer
1000
CPU
1001
System Memory
1003
1007
Input/Output Interface
1002
MCP
1004
NPU
1070
Support Circuits
1006
Input/Output
from/to Network
1005

FIG. 13

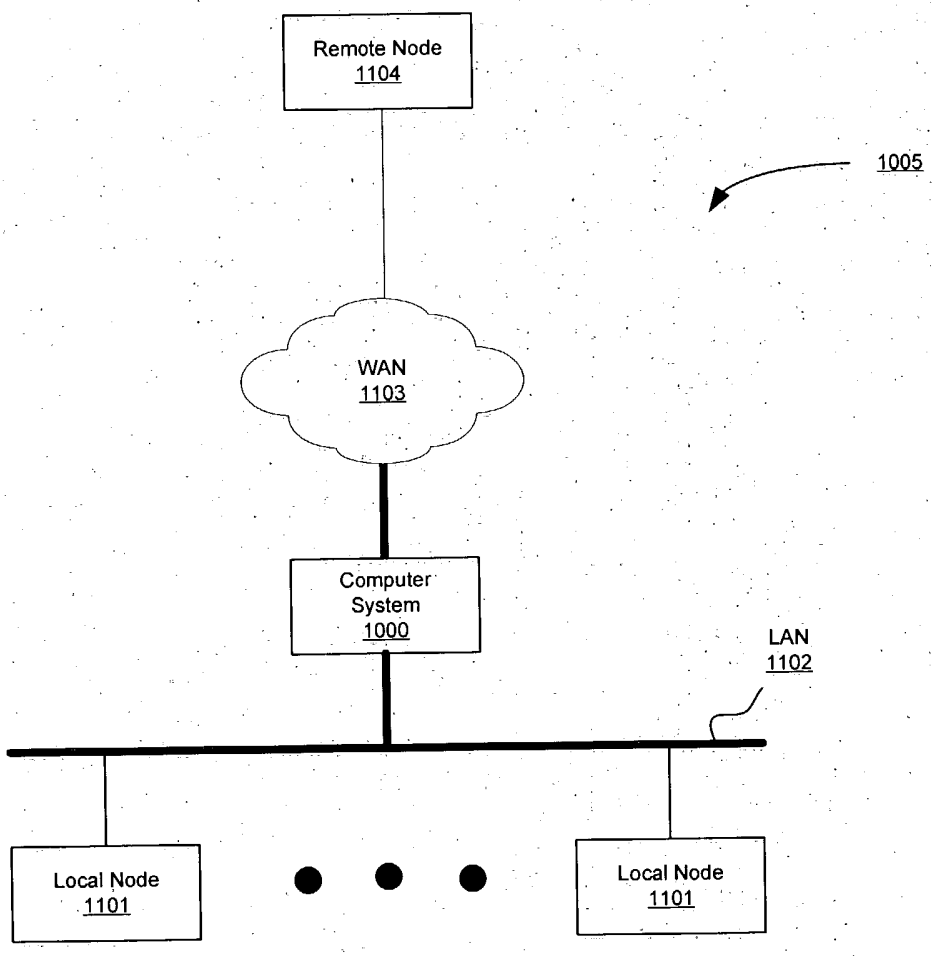
Remote Node
1104
1005
WAN
1103
Computer System
1000
LAN
1102
Local Node
1101
Local Node
1101

FIG. 14

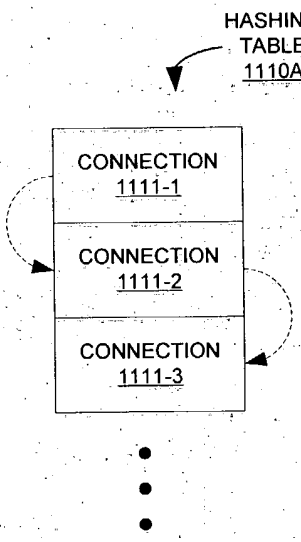

FIG. 15A

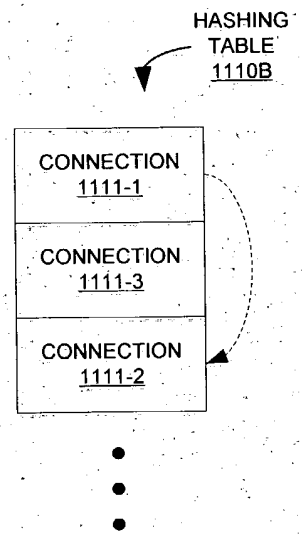

FIG. 15B

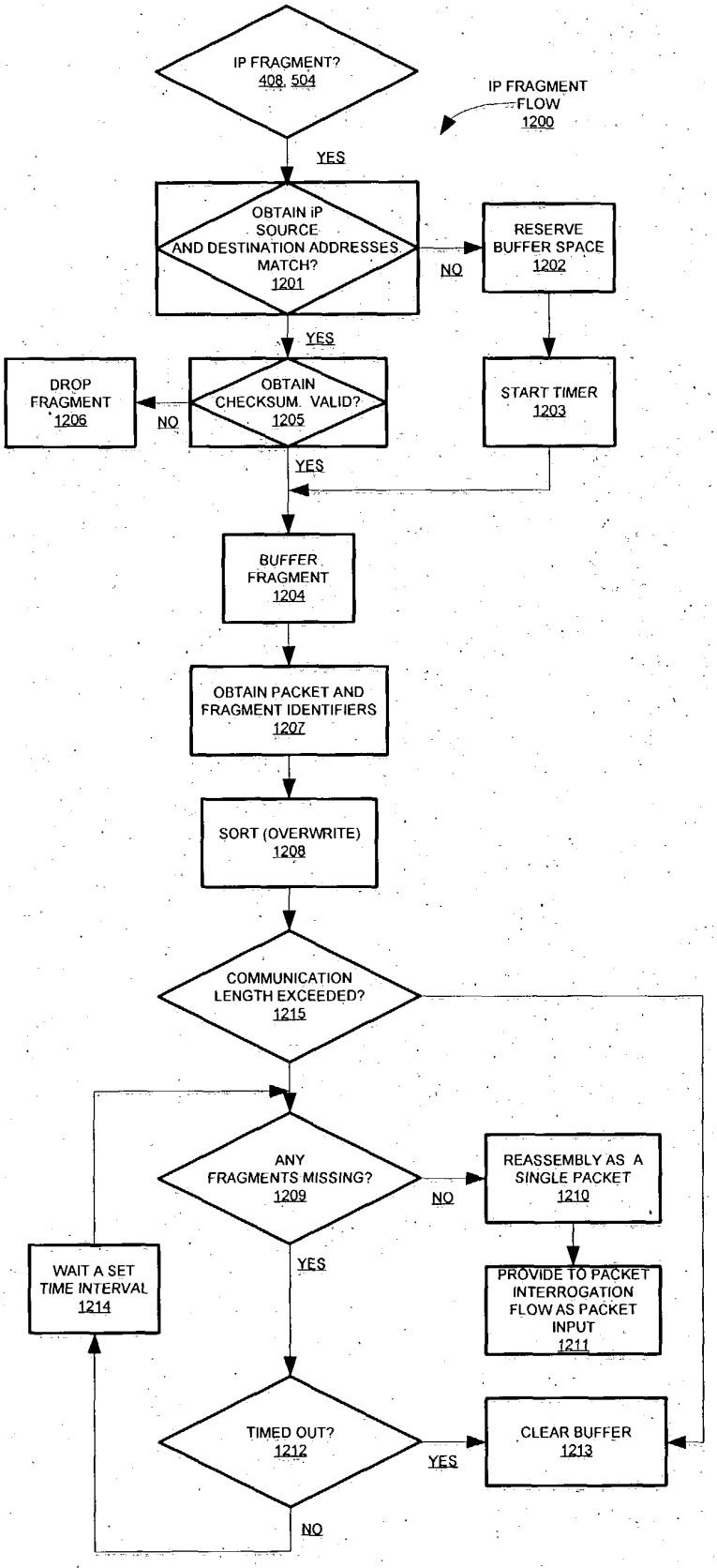
IP FRAGMENT?
408, 504
IP FRAGMENT FLOW
1200
YES
OBTAIN IP SOURCE AND DESTINATION ADDRESSES MATCH?
1201
NO
RESERVE BUFFER SPACE
1202
YES
DROP FRAGMENT
1206
NO
OBTAIN CHECKSUM. VALID?
1205
START TIMER
1203
YES
BUFFER FRAGMENT
1204
OBTAIN PACKET AND FRAGMENT IDENTIFIERS
1207
SORT (OVERWRITE)
1208
COMMUNICATION LENGTH EXCEEDED?
1215
ANY FRAGMENTS MISSING?
1209
NO
REASSEMBLY AS A SINGLE PACKET
1210
YES
PROVIDE TO PACKET INTERROGATION FLOW AS PACKET INPUT
1211
WAIT A SET TIME INTERVAL
1214
TIMED OUT?
1212
YES
CLEAR BUFFER
1213
NO

FIG. 16

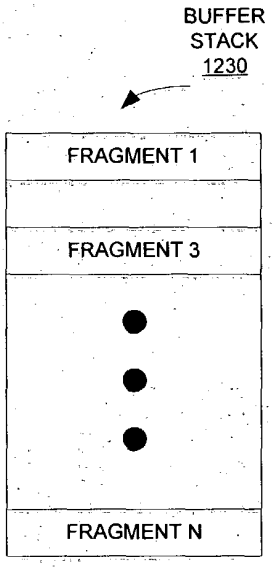
BUFFER STACK
1230
FRAGMENT 1
FRAGMENT 3
FRAGMENT N

FIG. 17